Center for Environmental & Applied Fluid Mechanics

"Hydrodynamic Performance and Scaling Laws for a Modeled Wave-Induced Flapping Foil Propulsion System"

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Wave-assisted propulsion (WAP) systems directly convert wave energy into thrust using elastically mounted hydrofoils. The wave conditions as well as the design of the hydrofoil drives the fluid-structure interaction of the hydrofoil and consequently, its performance. We employ simulations using a sharp-interface immersed boundary method to examine the effect of three key parameters on the flow physics, the fluid-structure interaction, as well as thrust performance of these systems - the stiffness of the torsional spring, the location of the pitch axis and the Strouhal number. We demonstrate the utility of 'maps' of energy exchange between the flow and the hydrofoil system, as a way to understand and predict these characteristics. The force-partitioning method (FPM) is used to decompose the pressure forces into interpretable components and to quantify the mechanisms associated with thrust generation. Based on the results from FPM, a phenomenological model for the thrust generated by the WAP foil is proposed. The predictions of the model are compared to the simulations and the use of this model for guiding WAP design is discussed. Next, the multifoil system is investigated where the wake of the leading foil is utilized to enhance the thrust of the trailing foils using both the model and numerical simulations.

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